Colvin (V.)

MAGNETIC OBSERVATIONS AT AND NEAR ALBANY, N. Y., BETWEEN THE YEARS 1686 AND 1892.

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Physical science affords no more interesting phenomenon than terrestrial magnetism. An invisible, yet potent omnipresent force, it is as important in its functions as is gravitation; and may, indeed, be a form or mode of energy supplementary to that greater power by which rivers run their courses downward to the sea. Terrestrial magnetism, however, differs from gravitation in being, even locally, an inconstant force; varying in accordance with its own local laws, and controlled by causes as yet little understood; yet penetrating and traversing even the massive mountains which gravitation holds so rigidly in place.

Every one appreciates the all-pervading nature of gravitation. Under its control the snow flakes fall steadily and regularly toward the earth. In obedience to gravitation the torrent of Niagara pours continuously into its gulf; and, at the command of this invisible force the Moon pursues the World; while the most distant planets, in their courses, majestically keep the orbits which the laws of gravitation prescribe.

When, after studying the wonderful symmetry and system of this great force, we encounter another mode of energy in matter, with an influence extending not only throughout the World but also — in all probability — throughout the Universe; associated with the phenomena of light, heat and electricity; we cannot but believe that this, the so-called terrestrial magnetism, is a condition of energy in matter that might be called, with better reason, *Cosmical Magnetism;* the natural magnetism of matter in space; and as much a portion of the celestial mechanism as gravitation itself.

It is true that the force controlling magnetism is, like electricity, invisible. When we speak of magnetism we refer to the reaction of this invisible force upon visible magnetic bodies; the substances we

call magnets, or those bodies susceptible to magnetism; and, by observing the varying movements of these bodies — suspended or otherwise so placed as to be free to the magnetic influence — we write down these movements, record the changes of pointing, trace the curves of motion, and find the intensity; until, by thus watching bodies controlled by the magnetic influence, we form some opinion of the invisible force that occasions these movements. Thus, with the aid of the various forms of magnetometer, we obtain mental concepts; ideals of the geometry of magnetic lines in space which, when systematized, may enable us, from a knowledge of the past events in terrestrial magnetism, to make predictions of future occurrences that will be of great benefit to mankind.

If for the theoretical "Ether" of school philosophies we substitute the idea of a *ubiquitous multi-mode energy;* ever existent in some ratio to matter, however infinitesimally attenuated this matter may be; we conceive an energy capable of an infinite variety of reactions, in accordance with the position or form of matter affected by it, and by this idea may arrive at a better conception of the nature of the phenomena of magnetism. Nor is this the only useful result of this modification of theory; for this conception of the energy of space, if it agree more closely and rationally with the facts of nature, may also, perhaps, account for all the so-called "physical forces," as resultants of the reactions of the diffused energy of space on the various local aspects of energy and matter.

It is not the purpose of the present paper, however, to consider or investigate the existence of a primal form of energy which shall replace in physical theory the "Ether" of the speculative philosophers. My views on this subject are already before the Institute.

The object of the present paper is to make public some new local magnetic data, with notices of other and more ancient records, which have hitherto escaped notice. It is thought best to accompany these observations with some calculations, which I have made by the formula considered by the chief mathematician of the United States Coast Survey the closest approximation so far made to the law of the magnetic declination at Albany, as a means of predicting the positions of the compass needle through its secular movement for many years to come. By comparing the computed predictions with the actual variation observed, not only is an idea had of the accuracy of this method of prediction — and, vice versa, of the irregularities in the actual movement of the needle as observed — but some notion also will be had of what is being sought by students of terrestrial magnetism, while the column of

differences, between the observations and predictions, will give an idea of the present degree of progress in this department of scientific research.

While avoiding, in this paper, any lengthy discussion of the nature of the energy of space; of force *per se;* as the cause of magnetic action; it is proper to call to mind some of the phenomena which, from their close connection with this subject, have made the expressions Terrestrial Magnetism and Cosmical Magnetism appear to be the proper titles for this branch of research.

The telescopic study of the Sun has shown that enormous disturbances of the solar atmosphere occur at times. Magnetic observations made upon the Earth, at moments identical with those of the solar disturbance, show that such solar action is synchronous with intense magnetic action at terrestrial stations. While we cannot prove that the solar disturbance is the cause of the magnetic disturbance upon the Earth, yet there appears to be a magnetic bond between the Sun and the Earth, through the apparently open intervening space, with a probability that the Sun is more nearly the centre of the origin, and the Earth the location of a resultant of the magnetic disturbance.

It is from this phenomenon that we obtain the mental concept of a primary or *Solar magnetism,* and a secondary or *Terrestrial magnetism.* It is a logical sequence of the instantaneous communication through space, of this mysterious influence, that there must be an energy and magnetism in space or *Cosmical Energy* or *Cosmical Magnetism;* an atmosphere of force, which probably controls both the magnetism of the Sun and its planets.

Hence by terrestrial magnetism is meant the magnetic atmosphere of the Earth; and "magnetic observations" are observations of the local action of this so-called atmosphere upon matter; the record giving an account of the visible movements of sensitively arranged magnets, or matter sensitive to magnetism, under the influence of this assumed magnetic atmosphere. The "magnets" of the magnetometers, or declinometers, are indices from whose movements we are able to form some opinion of the invisible, magnet-making Energy, the powers of which we seek to understand from its functions, by gauging, measuring or weighing its action on matter sensitive to its influence.

In every case the observations at any particular locality afford only what may be called a knowledge of the local magnetism; or, more properly — for we have no brief name for it — the condition of the cosmic magnetic energy, under the local influences.

It is to such observations of the local magnetic conditions at Albany, N. Y., at a great number of dates during the past two hundred years, that I desire to call your attention; and I particularly invite your attention to the record given of observations prior to the year 1817. Though these observations are few in number; only nine having been preserved between the years 1686 and 1807; yet they contain the most important date of *the epoch of the maximum easterly movement of the magnetic needle at Albany*, the observation nearest to this period having been made by the Surveyor-General of this State, Simeon De Witt, in the year 1805. The degree of maximum easterly movement, which is also the minimum westerly declination of the needle, was found by General De Witt to be $+4^{\circ}$ 58′ west of north from the true meridian at Albany on the 30th day of July, 1805.

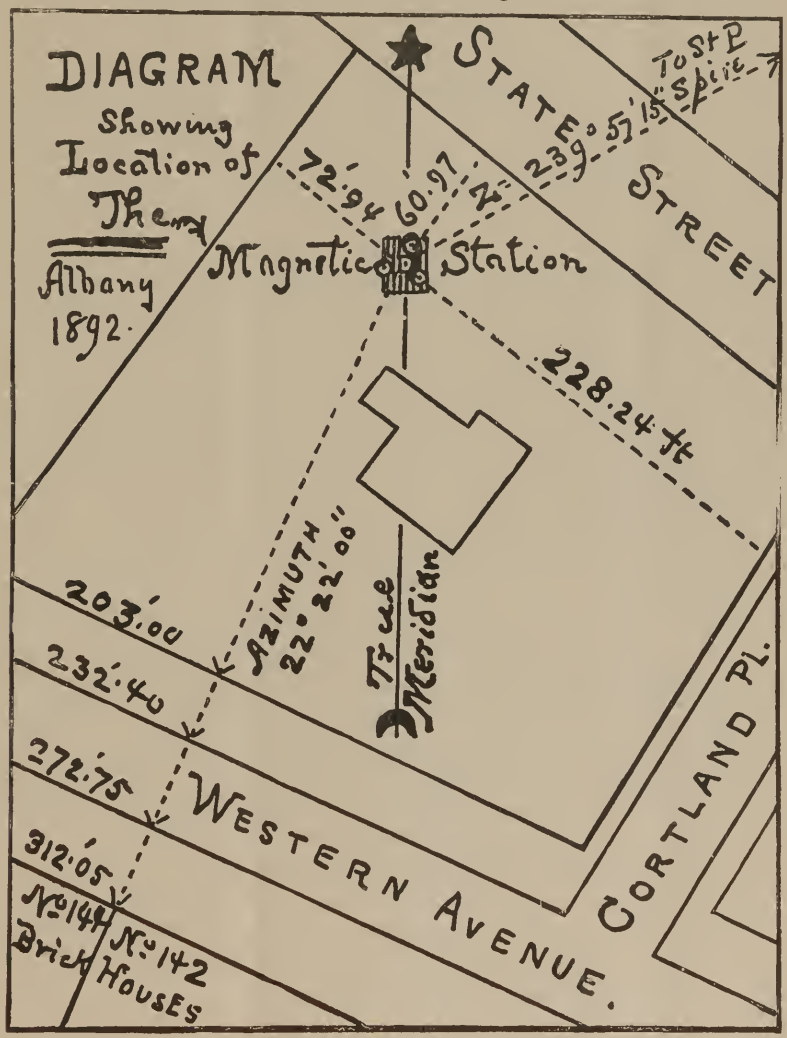
This result is so different from the value of the declination assigned to this date by theory, that I have been at great pains to see whether other and corroborating data could not be found. In this I have been successful; and, from records left by the late Prof. Joseph Henry, have found the declination in 1798 to have been $+5^{\circ}$ 00′ West of true North· which fully corroborates the view of General De Witt that the easterly movement of the magnetic needle at Albany continued until about the year 1805 (or 1807) and then suddenly changed to an annual westerly movement. That previously to this date, the magnetic needle at Albany had a continuously easterly movement, I have been able to satisfy myself from other data, of early surveys of the land patents in the vicinity of Albany. This unpublished data shows that in the year 1686 the magnetic declination at Albany was D = + 9° 09′ (North-west); in 1735, D = + 7° 40′ (North-west); in 1768 D = + 6° 39′ (North-west); in 1787, D = + 5° 03′ (North-west); in 1789, D = + 5° 27′ (North-west); in 1798, D = + 5° 00′ (North-west); in 1805, D = + 4° 58′ (North-west); indicating a decrease of declination as the year 1805 is approached; or a continuous easterly movement of the magnetic needle, as claimed by Surveyor-General De Witt, in his record of April 27th, 1825.

The fact that these more ancient observations differ entirely from what the present theory of local magnetism would indicate, makes them of the greatest importance as the key to a more accurate theory of the period and extent of the alternative progression and retrogression or secular movement of the magnetic force at Albany.

To this collection of ancient observations, I have added all those which are comparatively well known, so as to bring together all the data, of value for this investigation, in one paper.

The new data, being the observations at Albany of the magnetic declination between the years 1874 and 1892, are my own observations and are now for the first time made public.

My station of observation has been in the grounds of my residence on Western avenue in this city, and is marked by monuments and reference points which may hereafter be found and identified by means of the accompanying diagram. The magnetic station is marked by a brown-stone monument having a copper-plug, with cross, set as centre.



In the diagram the central circle is the brown-stone monument of the magnetic station; the other circles near this central station are the limestone piers of the astronomical instruments.

The geodetic coördinates of the brownstone monument are

LATITUDE = 42° 39′ 43″.63.
LONGITUDE, in arc = 73° 46′ 33″.48.
" in time = 4h. 55m. 06.23s. W. from Greenwich.
ALTITUDE = 227 $\frac{905}{1000}$th feet above mean tide level.

While there are several phases of the magnetic phenomena, usually investigated at permanent stations; as the intensity with which it affects magnetic matter, the dip angle and perturbations of these phases of its force, yet the "variation" or, more properly, the Declination of the magnetic needle has been chiefly studied by navigators and surveyors, as of immediate practical importance, and hence their records afford the most ancient data, and the best basis for magnetic investigations. When the intensity and dip have been fully correlated mathematically to the declination, we may be able to hope for a full knowledge of the general magnetic influence by means of observations of the declination alone.

The declination of the magnetic needle is to us, therefore, the most important reaction of the magnetic force upon matter; and it is for this reason, that I have specially studied, and made it the subject of the present paper.

I here, therefore, present in tabular form:

(1.) A collection of observations of the magnetic declination at Albany, N. Y.

(2.) A table showing prediction computations, which I have made by the mathematical formula hitherto regarded as the expression most conveniently representing the declination, according to the idea entertained by mathematicians, of the local magnetic law at Albany.

The formula, by which the results in table second were computed, was devised by Prof. Charles A. Schott, chief of the computing division of the U. S. Coast and Geodetic Survey at Washington. This formula he calls empirical. It was prepared many years since on the basis of the few observations then available for this locality.

The newly collected and observed data presented in this paper extends more than one hundred years back of the data which Prof. Schott used as the basis of his formula; and, doubtless, on this new data a more exact formula may be constructed.

I had hoped at this time to present a new formula of my own computation for this local magnetic law on the basis of the new data; but, as the time at my disposal has not been sufficient to permit me to assign weights (or estimates of precision) to each of the observations communicated, I must defer the pleasure of presenting this new formula until another time; and will merely transmit my observations and collated data, accompanied by computations by the old formula; which, while affording a scale of numerical comparison with the observations, will serve some present purposes, and give an idea of the supposed extent of the secular change in declination and of the processes, so far, devised for the prediction of the phenomena.

Using the old data only, the empirical formula of Schott for the magnetic declination at Albany is—

$$D = + 8°\cdot17 + 3°\cdot02 \text{ Sin } (1\cdot44\ m - 8°\cdot3)$$

in which D = the declination at any desired time in calendar years from the epoch 1850.

From this formula it will be seen that the terrestrial magnetic force is not as simple a form of energy as gravitation; especially in view of the fact that this is only one expression, suited to only one locality, and not applicable to any even moderately distant place.

This shows how important is the annual collection of local magnetic data, at a great number of points, if we are ever to attain a better understanding of the nature and origin of the magnetic force.

The computations in table (2) by the old formula I have extended beyond the limits for which they were probably intended in order to show the maximum and minimun points and numerical nature of the curve of declination according to Schott's formula, as well as to compare its values with the actual observations newly communicated in the first table. In this table the last column shows the ± differences of the results by formula from the actual observations.

With this explanation, this collection of data is herewith transmitted to the Institute, with the hope and intention that in a future paper these results will be discussed and some advancement made in the local theory and formula for the prediction of magnetic phenomena at Albany.

TABLE I.

Records of Observations of the Declination of the Magnetic Needle, at Albany, N. Y., between the years 1686 *and* 1892; *collected and observed by Verplanck Colvin.*

NOTE.—In 1609, September 13th, D = + 13° 00′ was observed by Robert Juet, sailing-master of Hendrick Hudson's ship, the Half Moon, on tide-water of Upper Hudson. The year 1680 was remarkable for five comets. In 1806 a remarkable total eclipse of the sun occurred, which General DeWitt thinks may have affected the earth's magnetism.

YEAR.	Date.	Declination.				Remarks.
1686	Month not given	+	9°	09′	North-west.	Early record, Van Rensselaer patent.
1735	Month not given	+	7	40	"	From notes of J. R. Bleeker, surveyor, etc.
1768	Month not given	+	6	39	"	From notes of J. R. Bleeker, surveyor, etc.
1787*	Month not given	+	5	03*	"	Records of Livingston manor.
1789	Month not given	+	5	27	"	New York Documentary History.
1798	Probably April	+	5	00	"	Prof. Joseph Henry.
1805	July 30th	+	4	58	"	Simeon De Witt.
1807	September 4th	+	5	43	"	Simeon De Witt.
1817	October 4th	+	5	44	"	Surveyor-General of State of New York.
1818	August 1st	+	5	45	"	Surveyer-General of State of New York.
1825	April 24th	+	6	00	"	Surveyor-General of State of New York.
1828	September	+	6	14	"	State geological survey.
1828	September	+	6	16	"	State geological survey.
1828	September	+	6	18	"	State geological survey.
1830	June	+	6	18	"	State geological survey.
1831	May	+	6	25	"	State geological survey.
1831	May	+	6	32	"	Geological survey.
1831	November	+	6	40	"	Regents' report and Silliman's Journal.

* Corrected to Albany Station D = + 5° 34′

1833	November	+	6	40	" ..	Regents' report and Silliman's Journal
1834	October	+	6	40	" ..	Silliman's Journal, 1838, vol. xxxiv.
1836	October	+	6	47	" ..	Silliman's Journal, 1838, vol. xxxiv.
1847	November	+	7	35	" ..	Regents' report.
1855	August 31st	+	7	54.7	" ..	Prof. C. A. Schott.
1856	September 1st	+	8	39.2	" ..	Karl Freisach, of Vienna.
1858	May 12th and 14th	+	8	17	" ..	G. W. Dean, U. S. C. Survey.
1874	July 25th	+	9	08.6	" ..	
1879	October 21st and 24th	+	9	51.7	" ..	
1880	April 10th	+	10	13.7	" ..	Verplanck Colvin, at station in grounds of his residence, between Western avenue and State street, Albany, N. Y.
1881	April 30th	+	10	20	" ..	
1882	April	+	10	12*	" ..	
1883	June	+	10	17*	" ..	
1884	June 3d	+	10	24	" ..	Latitude = 42° 39′ 43″
1885	May 22d	+	10	12.7	" ..	
1886	June 5th	+	10	16.1	" ..	Longitude = 73° 46′ 33″
1887	June 28th	+	10	21.3	" ..	
1888	April 25th	+	10	24.5	" ..	" in time $4^h\ 55^m\ 06^s$
1889	May	+	10	23*	" ..	
1890	July 19th	+	10	21.7	" ..	Altitude above sea level $227\frac{905}{1000}$ feet.
1891	February 3d	+	10	29.9	" ..	
1892	November 22d	+	10	37.0	" ..	

* Preserved on slips only; records mislaid.

TABLE II.

Probable Mean Magnetic Declination at Albany, according to Prof. Schotts formula.

[EMPIRICAL.]

YEAR.	Computed Declination.	Annual change.	Observed Declination.	Differences.
January 1st.				
1800	+ 5° 11′.5			
1801	5 12 .6			
1802	5 13 .6	+ 1′.04		
1803	5 14 .7			
1804	5 15 .7			
1805	5 16 .8		+ 4° 58′	+ 18′.8
1806	5 18 .4			
1807	5 20 .0	+ 1′.59	+ 5° 43′	— 23′.0
1808	5 21 .6			
1809	5 23 .2			
1810	5 24 .7			
1811	5 26 .9			
1812	5 29 .0	+ 2′.11		
1813	5 31 .1			
1814	5 33 .2			
1815	5 35 .3			
1816	5 37 .9			
1817	5 40 .5	+ 2′.60	+ 5° 44′	— 03′.5
1818	5 43 .1		5 45	— 01′.9
1819	5 45 .7			
1820	5 48 .3			
1821	5 51 .4			

1822	+ 5°	54′.4	+ 3′.05		
1823	5	57 .5			
1824	6	00 .5			
1825	6	03 .6		+ 6° 00′	+ 3′.6
1826	6	07 .0			
1827	6	10 .7	+ 3′.64		
1828	6	14 .3		+ 6° 14′	+ 0′.3
1829	6	18 .0			
1830	6	20 .9		+ 6° 18′	+ 2′.9
1831	6	24 .4		6 32.3	— 1 .9
1832	6	28 .0	+ 3′.59		
1833	6	31 .6		+ 6° 40′	— 8′.4
1834	6	35 .2		6 40	— 4 .8
1835	6	39 .8			
1836	6	43 .9		+ 6° 47′	— 3′.1
1837	6	48 .0	+ 4′.08		
1838	6	52 .1			
1839	6	56 .1			
1840	7	00 .2			
1841	7	04 .5			
1842	7	08 .8	+ 4′.30		
1843	7	13 .1			
1844	7	17 .4			
1845	7	21 .7			
1846	7	26 .2			
1847	7	30 .6	+ 4′.45	+ 7° 35′	—4′.4
1848	7	35 .1			
1849	7	39 .5			
1850	7	44 .0			
1851	7	48 .5			
1852	7	53 .1	+ 4′.53		

TABLE II — (*Continued*).

YEAR.	Computed Declination.	Annual change.	Observed Declination.	Differences.
January 1st.				
1853	+ 7° 57′.6			
1854	8 02 .1			
1855	8 06 .7		+ 7° 54′.7	+ 12′.0
1856	8 11 .2		8 39 .2	— 28 .0
1857	8 15 .8	+ 4′.54		
1858	8 20 .3		+ 8° 17′.0	+ 3′.3
1859	8 24 .9			
1860	8 29 .4			
1861	8 33 .9			
1862	8 38 .4	+ 4′.48		
1863	8 42 .9			
1864	8 47 .3			
1865	8 51 .8			
1866	8 56 .2			
1867	9 00 .5	+ 4′.35		
1868	9 04 .9			
1869	9 09 .2			
1870	9 13 .6			
1871	9 17 .7			
1872	9 21 .9	+ 4′.15		
1873	9 26 .1			
1874	9 30 .2		+ 9° 08′.6	+ 21′.6
1875	9 34 .4			
1876	9 38 .3			
1877	9 42 .2	+ 3′.88		

1878	+ 9 46′.0			
1879	9 49 .9		+ 9° 51′.7	— 1′.8
1880	9 53 .8		10 13 .7	+ 19 .9
1881	9 57 .4		10 20	— 22 .6
1882	10 00 .9	+ 3′.56	10 12	— 11 .1
1883	10 04 .5		10 17	— 12 .5
1884	10 08 .1		10 34 .5	— 26 .4
1885	10 11 .6		10 09 .1	+ 2 .5
1886	10 14 .8		10 16 .1	— 1 .3
1887	10 18 .0	+ 3′.17	10 21 .3	— 3 .3
1888	10 21 .2		10 24 .5	— 3 .3
1889	10 24 .3		10 23 .0	+ 1 .3
1890	10 27 .5		10 21 .7	+ 5 .8
1891	10 30 .3		10 29 .9	+ 0 .4
1892	10 33 .0	+ 2′.74	10 37 .0	— 4 .0
1893	10 35 .8			
1894	10 38 .5			
1895	10 41 .2			
1896	10 43 .5			
1897	10 45 .8	+ 2′.26		
1898	10 48 .1			
1899	10 50 .3			
1900	10 52 .6			
1901	10 54 .3			
1902	10 56 .1	+ 1′.75		
1903	10 57 .9			
1904	10 59 .6			
1905	11 01 .4			
1906	11 02 .6			
1907	11 03 .8	+ 1′.21		
1908	11 05 .0			

TABLE II — (*Continued*).

YEAR.	Computed Declination.	Annual change.	Observed Declination.	Differences.
1909	+ 11° 06′.2			
1910	11 07 .5			
1911	11 08 .1			
1912	11 08 .8	+ 0′.65		
1913	11 09 .4			
1914	11 10 .1			
1915	11 10 .7			
1916	11 11 .3			
1917	11 11 .9	+ 0′.60		
1918	11 12 .5			
1918.26 Maximum point W.	+11 13 .2			
1920	11 11 .2			
1925	11 09 .1			
1930	11 06 .7			
1935	10 55 .6			
1940	10 40 .0			
1950	10 16 .7			
1960	9 40 .5			
1970	8 58 .6			
1975	8 36 .3			
2,000	6 45 .9			
2,043	5 00 .0			
2,105.76 Minimum point by formula	0 00 .0			